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Ethical Issues of Brain Computer Interfaces (BCI)

(Draft)
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Introduction

Brain Computer Interface (BCI) technology is a powerful and rapidly developing form of technology which has a variety of potential applications for future development. BCI is any form of technology where a machine is connected to or directly controlled by the activity of the human brain. By its very nature BCI technology is suited for use both as a treatment for human's who have physical limitations resulting from an injury or illness and for the enhancement of the capabilities of humans who have relatively normal physical capabilities. This paper will examine the ethical implications of applying BCI technology both for therapeutic and enhancement uses. The ethical and technical issues presented by these two types of BCI use will be examined, and ethical principles will be employed to make recommendations about how best to approach the ethical and technical problems posed by therapeutic and enhancement uses of BCI.

Overview of BCI Technology

BCI technology provides a direct communication between the brain and an external device.¹ The electrical activity of the brain can be detected and interpreted by various machines and this activity can be used as data to control a computer, providing the direct communication link between the relevant human and machine. Electroenceelography (EEG), which is a method where electrical activity along the scalp can be measured, is one technology which can be used as a part of a non-invasive BCI system. Non-invasive BCI is any BCI technology which does not involve implanting a foreign device into the human user's brain. EEG is the most researched form of non-invasive BCI interface²

¹ Insert source for definition

² Nesta

Invasive BCI, is any system where the human user has a device physically implanted into their body, either in their brain or in another part of their body, where nerve impulses can be used to communicate directly with the external component of the BCI system. There are numerous examples of both invasive and non-invasive BCI systems and there are separate considerations which must be made when working with these two different types of systems. The primary advantage of invasive BCI methods is that they usually produce stronger signals than non-invasive BCI. This allows for more effective BCI systems, in terms of the user having more consistent and precise control of the external mechanisms of the BCI system.

There are some obvious disadvantages of invasive methods in comparison to non-invasive methods. Invasive BCI systems must be implanted surgically, which can introduce risks associated with any type of surgery. Implantation surgery, and the presence of a foreign object within a human's body, can create scar tissue in the area around the implantation. Scar tissue build can even cause the relatively stronger signal to weaken or be lost altogether, thus negating the primary advantage of using invasive BCI. Additionally, there is the inherent risk that the implant will malfunction or simply wear out, and if the implant has to be removed for maintenance, additional surgery will be necessary.

Various Forms of BCI Technology

BCI technology has been developed in a number of various forms, with differing mechanical and electrical mechanisms, some which do not even involve humans. Cultured neural networks³ are a form of BCI where neurons are hosted in a culture dish in a laboratory. The electrical activity which develops among the cultured neurons can be used to control external devices, such as the “rat-brain robot” developed by Kevin Warwick at the University of

³ Insert source

Reading⁴. In this system Warwick and his team have taken the brain cells of a rat, cultured them, and used them to control simple wheeled robots⁵. Researchers have also created external robotic appendages which can be controlled by the user's brain⁶. Experiments at Duke University have been conducted to test the use of such robotic appendages by rhesus monkeys via implants placed in the monkey's brains⁷. There are also BCI systems where devices are connected to the user's body and function as part of their body, as a replacement for a missing limb.

Therapeutic Uses of BCI

It is easy to imagine how BCI technology could potentially be used to assist people who have suffered catastrophic or life-altering injuries or illness. Among therapeutic applications, experimental BCI devices have been developed to assist people who have suffered paralysis, have lost limbs, or have lost the ability to see. Therapeutic BCI devices come in various forms and utilize different devices to aid the relevant patient. One example is the Dobelle artificial vision system⁸. With this system the patient has an implant placed in their brain and wears a pair of glasses which are fitted with a miniature video camera⁹. A signal processor translates the images captured by the camera into a series of signals which can be understood by the brain, which in turn sends this information to the brain implant and in theory allows the patient to "see" the image which reaches his glasses.¹⁰

The Lifehand project is an experimental BCI system where a mechanical appendage is actually physically connected to a person's body and controlled by that person's nerve activity¹¹.

In 2009, as part of the Lifehand project, Peripaulo Petruzzello had a BCI implant inserted into

⁴ Saenz

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¹¹ Nesta

the nerves of his upper arm¹². After receiving the implant Petruziello, who had his hand and forearm amputated after a car accident, was able to control a bionic arm attached to him via electrodes.

Another example of BCI is the Braingate device¹³. Braingate is an aspirin-sized implant which is placed into the brain and allows the recipient to manipulate external devices¹⁴. The Braingate Neural Interface device is implanted on the motor cortex of the brain and analyzes and interprets brain signals in order to perform tasks such moving a computer cursor¹⁵. The Braingate Company, envision future devices benefitting individuals who are not paralyzed, but who may be suffering from conditions which restrict breathing, bladder functions and bowel movements.¹⁶

Therapeutic BCIs

Therapeutic BCIs are used to restore capability to people who have suffered some injury or who were born with a disability. In the past 15 years, there have been many experiments with therapeutic BCIs. In 1998, doctors Roy Bakay and Philip Kennedy worked at Emory University to treat a 53-year old man, known as J.R., who had suffered a brain stem stroke. He was left with locked-in syndrome, a medical condition in which a person is conscious and aware, but almost completely paralyzed. People with locked-in syndrome can typically move only their eyes, so they are robbed of virtually all methods of communication, notably speech. There also exists a condition called total locked-in syndrome, which is a complete paralysis of all muscles, including those controlling the eyes. The doctors placed electrodes into glass tubes coated with neurotropic chemicals extracted from J.R.'s nerves. This was implanted into his brain, creating a hard-wired connection to a computer because his neurons can attach to the electrodes. This

¹² Nesta

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¹⁴ Braingate

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¹⁶ Braingate

allowed J.R. to move a cursor around on a computer screen to select letters or phrases, restoring some of his ability to communicate.

Dr. Dobelle¹⁷ was a researcher who dedicated much of his life to experiments to restore sight to blind people. He began working on the concept of artificial vision in 1968. As of 2003, Dobelle himself had privately treated 13 blind patients with BCIs to restore a semblance of vision. He passed away in 2004, but his companies produce devices that have been implanted in over 15,000 patients throughout the world.

In 2001, a man named Matt Nagle was stabbed, severing his spinal cord and leaving him paralyzed from the neck down. Several years later, he was implanted with a computer chip as part of a study for Cybernetics' BrainGate technology. This BCI enabled Nagle to not only control a computer cursor to press buttons, but also to move a robotic arm (to a limited extent).

Most BCI technologies have been invasive, requiring surgery to directly attach computer components to a patient's brain. There have, however, been advances with non-invasive BCIs, like the Intendix by g.tec. This cap allows patients to select letters and number from a grid with flashing rows and columns simply by thinking about a particular symbol for several seconds. They also provide an additional tool called Extendix that works in conjunction with the Intendix to control other devices and applications like television, music, video games, and even robots.

Technical Issues with Therapeutic BCIs

Several major technical issues must be addressed in the discussion of therapeutic BCIs. First, is the problem of obtaining informed consent from potential patients. Informed consent is a patient's agreement to receive certain medical treatment after being fully advised of the related

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facts and possible risks associated with the surgery or procedure. For certain patients of BCIs, getting informed consent is not a problem at all. For example, Dr. Dobelle did not have trouble informing his blind patients about treatment, as they could still hear and speak. For patients with locked-in syndrome, it is a bit more difficult to obtain their consent. Doctors must establish some kind of communication code with the patient. One of Dr. Kennedy's patients, for instance, pointed his eyes to the left to indicate "yes" and to the right to indicate "no." Patients with total locked-in syndrome have no way to communicate with the world, and so for them the technical issue of informed consent transforms into an ethical issue: is it ethical to implant a patient with a BCI when the doctor cannot obtain their informed consent?

Another issue with all BCIs is that of durability. The manufacturers of BCIs must determine how long their devices will last under normal circumstances, as well as possible accidents. Eventually, such devices may need to be replaced in part or in whole, and the patient's safety comes into play. Surgical procedures are inherently dangerous, and it is therefore in the interest of both the producers and consumers of BCIs to have technology that will withstand natural deterioration and physical trauma. The related problems of product durability and patient safety are generally addressed legally with warranties, which ensure the quality of a product and specify how the manufacturer will handle problems with it, usually for a limited amount of time after purchase. BCIs are part of a gray area between normal products and medicine, so a limited warranty alone would probably not handle all the issues of durability and safety.

Making therapeutic BCIs available to people in need is another technical problem with questions that are difficult to answer because the technology is still so new. How will BCIs be distributed to patients throughout the world? Invasive BCIs would require surgeons educated specifically in brain implantations, so it is likely that people in more rural areas would have to

travel some distance to get surgery. Disabled patients can be divided into two categories: people born with some condition that makes them less capable than the average person, or people who lost capability later in life through some accident. If only a limited number of BCIs were available in a region or span of time, would one kind of patient get preference over the other? How would BCIs be incorporated into medical plans? Would they be covered by most insurance, or would specific details of the situation preclude lots of people from treatment? As with current medical procedures, affordability of treatment would be another major issue. Is it even plausible that BCIs could be made affordable to the average patient? It is probable that people with more money will always be able to receive better treatment than those with less. BCIs will therefore be more prevalent in first-world countries. It is difficult to make many concrete statements about this technology yet, but therapeutic BCIs will definitely become more popular and affordable in the future, and it remains to be seen how the providers will deal with the related technical problems.

Ethical Issues with Therapeutic BCIs

The use of BCIs is still rather controversial. One ethical problem is whether it is permissible to use BCIs to treat patients when their informed consent cannot be obtained. This is only an issue with people who are completely unable to communicate (like those with total locked-in syndrome). There are several ways to address the problem. Most patients who cannot communicate probably have family members acting as legal guardians, and the doctors can inform them about the procedure and obtain their informed consent because they are responsible for the patient. In this way, the guardian has established a legal contract with the doctor. If a patient does not have any legal guardian, then the question remains. Should doctors refuse to treat a person who is unable to legally agree to surgery, or should they treat the person with the

aim of simply trying to improve the person's life? This problem is encompassed by the larger question of whether it is ethical to perform BCI surgery at all. This question can be viewed through two lenses: is it ethical to intentionally violate a person's body, even for therapeutic reasons? Or, is it unethical to use BCIs at all because by doing so we are “playing God?”

Consequentialism is an ethical theory that it is moral to act in ways that produce good outcomes and avoid bad ones. The Principle of Utility states that actions are ethical which create the most happiness or pleasure for the most people and the least unhappiness or pain for the most people after considering everyone's perspective. According to this principle, treatment with BCIs is moral because it aims to improve the lives of people who have been disabled.

The ACM Code of Ethics and Professional Conduct can also be used to address the ethical issues with therapeutic BCIs. Guideline 2.5 is “Give comprehensive and thorough evaluations of computer systems and their impacts, including analysis of possible risks.” This is exactly what a doctor must do when informing a patient about BCI treatment. As long as the doctor obtains a patient's informed consent, they are acting ethically and professionally in accordance with the ACM Code of Ethics.

Therapy is just one aspect of the use of BCIs. The technology has made great strides in the past 20 years, with some devices, like the Intendix, already available to the public. In the future, therapeutic BCIs will become more and more prevalent as people realize that it may be possible for them to restore lost capability.

Potential use of BCI for Performance Enhancement

Just as it is easy to imagine the many possible therapeutic uses of BCI technology it is also easy to imagine how this technology could be used to enhance the performance of humans

who are already functioning at a ‘normal’ level. It is instructive to look at some possible enhancements which could be achieved by utilizing the therapeutic BCI devices in a different manner than previously intended. It is possible for any therapeutic BCI device to be adapted for use as a performance enhancer.

Artificial vision systems could be adapted to allow a human user to detect light in a different range of the electromagnetic spectrum than they would naturally be capable of seeing. An artificial vision system could be designed to give the user instant access to infrared, ultraviolet or other types of vision, perhaps by simply changing the settings on the implant or the glasses used in a system similar to that of the Dobelle system. Such a system could be implanted in any person, as long as the implantation process and device design were at a level of refinement where the side effects of the implant were negligible.

The logical extreme of the Lifehand project would be the creation of artificial limbs capable of greater strength or dexterity than any natural human limb. A sufficiently developed system might allow for the creation of super-human powers or skills by replacing a healthy human’s limbs with bionic limbs and training them to use these limbs via brain implants. The Braingate device could theoretically be placed in the brain of a human for the purpose of allowing that human to manipulate objects with his or her thoughts. A sufficiently sophisticated Braingate type system could allow humans to control extremely powerful objects with no physical exertion.

With such devices humans would be capable of telekinesis. Even non-therapeutic systems, such as the “robot with a rat-brain” cultured neural network system, could be used to control heavy robotics. The cells in these networks can form new connections, and could be

capable of learning.¹⁸ One logical extreme of this type of technology is the development of cyborg animals¹⁹.

Stakeholders – Therapeutic BCI

When examining therapeutic BCI the primary stakeholders are the medical and scientific professionals conducting experiments with BCI systems and any injured people who are participating in clinical trials to test these systems. An ethical question for medical professionals is how to proceed when trying obtain the consent of patients who are so profoundly paralyzed that it is nearly impossible from them to communicate. This is concern for the medical professional as well as the patient. Patients and the researchers conducting experiments also have to weigh the potential risks of implantation and usage of BCI devices.

People who are injured, and who may be helped by existing BCI devices but who are not currently participating in a clinical trial would be secondary stakeholders. Even when devices and systems are in an early stage of development, they can offer a great deal of hope for people who are faced with the challenges presented by paralysis, amputation of limbs or other catastrophic, life-altering injuries. People who might be helped by BCI devices will likely be interested in learning about them and perhaps becoming part of a clinical trial to test them, regardless of the risks that may be posed by using relatively new devices. Health insurers are secondary stakeholders, since they will be interested to see what BCI systems are available for patients who are policyholders, how effective these devices are, how safe and reliable they are for the patient, and how much they may cost when they progress past the experimental stage and are approved for medical use.

Stakeholders – Enhancement BCI

¹⁸ Saenz

¹⁹ Saenz

The far reaching possibilities of enhancement BCI indicate that there are a great number of potential stakeholders. The types of potential enhancements would be of great use in combat situations, and national governments would be a primary stakeholder when discussing enhancement BCI. National governments are best equipped to develop and exploit such technologies because of the immense resources that they can employ.

Military forces and law enforcement would be keenly interested in the possibilities presented by using BCI for human performance enhancement. Armed forces (again either military or law enforcement) which include enhanced soldiers, could possibly have immense advantages relative to adversaries who employed members who did not have any BCI enhancements. If enhanced soldiers are a significant advantage in combat, this could further widen the gap in military capabilities created by the technological sophistication of various nations. Law enforcement use of BCI enhancement must also face ethical questions because it could increase the physical capability of police forces to point at which a significant number of citizens are uncomfortable with the level of those capabilities.

The general public is a secondary stakeholder when examining enhancement BCI. In a country where military or police forces are equipped with significant BCI enhancement the general public may become concerned that there is too much power concentrated in the hands of the government. Parents may also be troubled by the questions that can be raised if enhancement BCI becomes available to some, but not all of the general public. If children can be outfitted with BCI systems which will increase their physical or mental capacity it is not clear how such systems could be used in a way which is deemed fair by a majority of the public. If only wealthy people can afford BCI enhancements for their children, this is similar to the children of the wealthy having access to superior private schools, or is this an entirely different form of

advantage for the privileged. There are a number of other ethical questions which can be raised about the use of BCI for enhancement both at the individual level, and as it relates to larger entities such as entire nations.

BCI Enhancement Summary

There are a number of ethical issues with BCI's used for enhancement. We focused on two certain scenarios: using BCI's to allow soldiers to communicate via recognizable brainwave patterns that are instantaneously transmitted to the other troops (essentially technology-generated telepathy), and a "military human augmentation suits" by using a BCI controlled exoskeleton.

BCI's are being developed where sensors in the soldiers helmets can detect the brainwaves that the soldiers have when thinking, interpret the words that are being thought, and then send them out to other soldiers, so everyone in the group can hear it. This would eliminate the need of talking between soldiers in a battle, which could make communication to all soldiers easier to manage in a hostile environment.

The exoskeletons that are being developed can either be invasive (implanted directly into the muscles/brain) or non-invasive (sensors located that can detect the signals sent to and from the brain/muscles). They would allow a person to think about moving their muscles and at the same time control a suit that has much more capabilities than the human body. This enhancement could allow a soldier to carry much more gear and move a more in less time while using less energy than normal. It could also give soldiers more endurance in a battle situation.

BCI Enhancement Technical Problems

Although there are many obvious benefits from BCI enhancement technology, there are also serious technical problems that could result from having them. One possible problem that will definitely come into question is, “What if the BCI stops working if it’s implanted inside someone?” This could cause many problems to not only a soldier in battle, but also if just used as an enhancement to a normal person.

If a soldier in battle is communicating orders and the BCI fails, then there could perhaps be no other way to get the orders to every single soldier, and this could jeopardizing the entire mission while endangering human life. If a human exoskeleton fails during a mission, it could cause a lost of the gear that they were trying to carry and could have to be given to other soldiers, to be left behind entirely.

Finally, what if the BCI does more physical harm than good? There is a possibility that having a BCI could exhaust your body more by using the exoskeleton, causing a lot more wear and tear on your muscles and brain, and possibly taking years off your life.

BCI Enhancement Ethical Problems

There are also ethical problems that could come from the use of enhancement BCI’s. We analyzed the ethical problems that come from enhancement BCI’s with the ethical principles of virtue ethics, deontology, divine law, and consequentialism.

By the principle of virtue ethics, the principle that uses the virtues and character of a person before the consequences of actions to assess the basis of a person’s ethics, it could be questioned if a person could use the enhancements to cheat at something like sports or scholastics. For example, a student could use the communication BCI to think the answers to a quiz or exam and let some of the other students hear them. A person could also use that

technology to give players an advantage in sports by communicating plays or moves to other players giving them an obvious advantage.

Using the ethical principle of deontology, there are more ethical issues that arise with enhancement BCI's. The most obvious problem is the question, "Is it our duty to add computers to enhance the abilities of humans?" Some people will think that it's not our duty to add a machine or computer to a person, and that creating a "cyborg" only for enhancement purposes is unethical.

By looking at BCI's from the perspective of consequentialism, the principle that bases a person's ethics on the consequences of their actions, another problem could come up. Will the enhancements of BCI's do more harm to society than good? It could be argued that the BCI enhancement technology could easily be used by a criminal or terrorist organization to make crimes easier in many ways, so having those negative outcomes would be very detrimental to society.

BCI Enhancement Social Problems

Adding enhancement BCI to a person could encourage discrimination against people with BCI's because of what they could say about a person's disabilities, wealth and even just having one in general, which would be a harm to society as a whole. There would also have to be a very thorough list of the risks and harms of using a BCI so that a person could know both sides of the story, good and bad things that come from it. Lastly there would have to be clear contracts and warranties associated with each BCI, so who is responsible for something that goes wrong with them and who is responsible for replacing them.

Recommendations

Regarding therapeutic BCI devices they should be fully available to those who need them. If a BCI device is the best option for a given patient's disability, it should be a fully integrated option under that patient's health care provider. Unforeseen changes in the healthcare system aside, all realistic attempts to make it feasible and affordable should be taken. At the same time, regardless of whether the BCI device is the best solution or not, the procedure should always be the patient's choice. ACM code of ethics 2.6, honor contracts, agreements and assigned responsibilities. If the patient doesn't expressly agree to receive the device, no medical procedure should be performed of this nature. The concept of informed consent should be strictly adhered to in all cases. From an ethical standpoint, via Contractarianism the procedure is inherently moral if the patient consents to its undertaking. Even in the case of patients with limited to no ability to communicate, consent should be sought. Even one blink for yes two for no will suffice.

Regarding enhancement BCI. We recommend a BCI device should never be forced on an individual in a given field or position. Upholding the ACM code of ethics section 1.4 and 1.2, be fair and take action not to discriminate, and do no harm to others. Violating an individual's right to refuse such a procedure under any circumstances could be considered to be doing both physical and emotional harm. In addition, this could be considered a form of discrimination. Implying that they are somehow inferior and will not be given the same opportunities as their counterparts until the subject themselves to implantation of a BCI device. From an ethical standpoint, Kant's second categorical imperative states that humanity should be treated as an end and never the means. Enhancement as a means to that end without the consent of the patient would be in direct violation. Brain-Computer Interfaces and other similar devices have the potential to solve many of mankind's medical and social problems. They also have the potential

to cause a whole slew of new ones. How we deal with them as a society will determine the outcome of such devices' widespread use. It seems apparent that these issues will appear in the near future. If handled correctly, humanity as a whole will be much improved in nearly all aspects imaginable.

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